Ontario

Apprenticeship
In-school Curriculum Standards

Instrumentation and Control Technician

Level II

447A

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Implementation date: November 2007
Printing date: June 2008

ISBN 978-1-4249-6836-7 (Print)
ISBN 978-1-4249-6837-4 (PDF)

Printed on recycled paper

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08-164

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Introduction

This Instrumentation and Control Technician Curriculum Standard has been developed in keeping with the Common Format Guidelines prescribed by the Ministry of Training Colleges and Universities (MTCU) from the trade workplace Performance Objectives. The curriculum standard reflects the content necessary for appropriate progression through each level of the Instrumentation and Control Technician in-school apprenticeship program.

For easy reference, a time allocation has been included for each respective reportable subject and units, along with a breakdown of theory and application in the delivery of the learning objectives.

The continual introduction of innovative techniques and more complex equipment is resulting in increasing demands for service technicians who are not only skilled in the practical aspects of the trade, but who also have a sound theoretical knowledge of the testing, diagnosing and servicing requirements. The curriculum standard has been developed to provide this theoretical knowledge and to offer some practical applications to complement the on-the-job work experience of the Instrumentation and Control Technician.

The curriculum standard has been designed to give the instructor every opportunity for flexibility and innovation without significant departures from content. Since the scope of the prescribed curriculum standard is quite extensive, the apprentice will be expected to reinforce the acquired knowledge through regular independent out-of-classroom assignments.

The curriculum standard includes specific references to the apprenticeship on-the-job training standards. While terminal performance objectives in the training standards have been linked to the respective in-school learning outcomes and learning content objectives, employers should not assume complete coverage in all aspects of the objectives. The in-school delivery focuses primarily on the knowledge required and fundamental skills that support the respective performance objectives outlined in the workplace training standards. Employers are expected to complete the delivery of these objectives by applying the prescribed in-school knowledge to the practical learning experiences in the work setting.

Regular evaluations of an apprentice's learning achievements must be performed in both theory and practical applications throughout the program.

Program Summary of Reportable Subjects

Number	Reportable Subjects	Hours Total	Hours Theory	Hours Practice
S0375	Electrical Theory and Applied Trade Calculations II	48	36	12
S0376	Instrumentation II	63	30	33
S0377	Instrumentation Controls I	54	29	25
S0378	Discrete Control	36	16	20
S0379	Computer Control Systems	39	14	25
	Total	**240**	**125**	**115**

Program Summary by Reportable Subject & Evaluation & Testing

Number:	S0375
Title:	**Electrical Theory and Applied Trade Calculations II**
Duration:	Total Hours: 48
	Theory: 36 Hours Practical: 12 Hours
Prerequisites:	None
Co-requisites:	None

Evaluation Structure:

- Assignments related to theory and appropriate application skills.
- Final exam at end of term.
- Periodic quizzes.

Theory Testing	50%
Practical Exercises	20%
Final Assessment	30%

Reportable Subject

Number:	S0375.1	
Title:	Principles of Magnetism	
Duration:	Total Hours:	6
	Theory:	4
	Practical:	2
Prerequisites:	None	
Co-requisites:	None	

Cross-Reference to Training Standard Performance Objectives: 6423.0, 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.0, 6430.0, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOME

On successful completion, the apprentice is able to describe magnetic principles and solve problems as applied to the operation of transformers.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

1.1.1 Define the principles of permanent magnetism.

1.1.2 Define the principles of electromagnetism.

1.1.3 Solve problems associated with magnetic energy as related to transformers.

1.1.1 Define the principles of permanent magnetism.

- Define and observe characteristics of permanent magnetism
  - properties of permanent magnets
  - action of magnetic poles
  - magnetic fields
  - magnetic properties

1.1.2 Define the principles of electromagnetism.

- Define and observe characteristics of electromagnetism
  - properties of electromagnets
  - action of magnetic fields around a conductor
  - principles of induced voltage
  - effects of motion on induced voltage
  - factors that affect induced voltage
  - define Lenz's Law
  - describe the creation and effects of eddy currents

- Describe magnetic flux and flux density
- Explain Ohm's law as applied to magnetic circuits

1.1.3 Solve problems associated with magnetic energy as related to transformers.

- Power Ratings
- Turns Ratio
- Frequency Effects

Number: S0375.2

Title: Magnetic Devices

Duration: Total hours: 6

Theory: 6
Practical: 0

Prerequisites: None

Co-requisites: None

Cross-Reference to Training Standard Performance Objectives: 6429.01, 6429.02, 6429.03, 6429.04, 6429.05, 6429.06, 6429.07, 6429.08, 6429.09, 6429.10

GENERAL LEARNING OUTCOME

On successful completion, the apprentice is able to describe the operation and perform inductance calculations related to magnetic devices such as; solenoids and relays according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

1.2.1 Describe operating characteristics of magnetic devices.

- Solenoids
- Relays
- Linear Voltage Differential Transformers (LVDTs)

1.2.2 List and explain the factors that affect the magnitude and direction of induced EMF in single conductors and in coils

1.2.3 Describe factors that affect inductance and perform related calculations

- Inductance
- RL Circuits

Number: S0375.3

Title: Capacitors, Inductors and Resistive Devices

Duration: Total hours: 16

Theory: 10
Practical: 6

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6423.0, 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.16, 6429.18, 6430.01, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to build circuits and test the operating characteristics of capacitors, inductors and resistive devices as applied to DC and AC motors, impedance networks and polyphase circuits.demonstrate the ability to select materials used in the trade.

LEARNING OUTCOMES

Upon successful completion the apprentice is able to:

1.3.1 Describe the effects of alternating voltage and current in a resistive device.

1.3.2 Describe the characteristics of a coil connected to an AC source.

1.3.3 Describe inductance and characteristics of a coil connected to a DC source.

1.3.4 Describe capacitance, and characteristics of a capacitor connected to a DC source.

1.3.5 Describe the characteristics of a capacitor connected to an AC source.

1.3.6 Describe and explain resonant circuits (RLC).

1.3.7 Build and test RC, RL and RLC circuits.

Number: S0375.4

Title: AC Motors And Generators

Duration: Total hours: 14

Theory: 10
Practical: 4

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6423.0, 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.16, 6429.18, 6430.01, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to describe the construction and operating characteristics of AC motors and generators according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion the apprentice is able to:

1.4.1 Define the fundamentals and applications of AC motors for instrumentation and control systems.

1.4.2 Identify the components used in single phase and three phase Squirrel Cage Induction Motors (SCIMs).

1.4.3 Explain the operating principles of AC motors for instrumentation and control systems.

1.4.4 Explain the operating principles of single phase and three phase Squirrel Cage Induction Motors (SCIMs).

1.4.5 Describe AC motors.

1.4.6 Define the fundamentals of AC generators for instrumentation and control systems.

1.4.1 Define the fundamentals and applications of AC motors for instrumentation and control systems.

- Motor action (AC)
- Rotating field
- Armature rotation
- Simple AC motor

1.4.2 Identify the components used in single phase and three phase Squirrel Cage Induction Motors (SCIMs).

- Single phase induction motors
  - Housings
  - Armatures
  - Bushings/bearings
  - Brushes/springs
  - windings

- Three phase induction motors
  - Housings
  - Armatures
  - Bushings/bearings
  - Brushes/springs
  - windings

1.4.3 Explain the operating principles of AC motors for instrumentation and control systems.

- AC motor performance characteristics
  - torque
  - current draw

- Describe a sine wave, calculate root-mean-square (RMS), and average, maximum, and instantaneous values

1.4.4 Explain the operating principles of single phase and three phase Squirrel Cage Induction Motors (SCIMs).

- Single phase induction motors

- Three phase induction motors

1.4.5 Describe AC motors

1.4.6 Define the fundamentals of AC generators for instrumentation and control systems.

- Electromagnetism pertaining to motor generator action.
  - induction
  - factors that determine induced EMF strength
  - effects of motion on direction of current

- Explain the construction features of AC generators for instrumentation and control systems.

  - Windings
  - Field poles
  - Slip rings
  - Armature
  - Brushes, springs and holders

- Explain the operating principles of AC generators for instrumentation and control systems.

  - direction of induced voltage
  - Fleming's right hand rule
  - induced voltage and current
  - voltage output waveform
  - commutation

- Explain and calculate frequency, electrical and mechanical degrees.

Number: S0375.5

Title: DC Motors and Generators

Duration: Total hours: 6

Theory: 6
Practical: 0

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6423.0, 6424.0, 6425.0, 6426.0, 6427.0, 6428.0, 6429.16, 6429.18, 6430.01, 6431.0, 6432.0, 6433.0, 6434.0

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to describe the construction and operating characteristics of DC motors and generators according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

1.5.1 Define the fundamentals and applications of DC Motors and Generators.

1.5.2 Describe the construction features of DC Generators and Motors.

1.5.3 Explain the operating principles of DC Generators and Motors.

1.5.1 Define the fundamentals and applications of DC Motors and Generators.

- Describe and explain the operation and characteristics of DC motors and generators

1.5.2 Describe the construction features of DC Generators and Motors.

- DC generator circuits
  - commutator
  - main frame
  - pole pieces
  - armature
  - types of field windings, series, shunt and compound
- Name plate data

1.5.3 Explain the operating principles of DC Generators and Motors.

- Trace motor circuit current flow

S0375: RECOMMENDED MINIMUM EQUIPMENT:

- Variety of capacitors, inductors, transformers, AC & DC motors
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Oscilloscope and X10 probe
- Variable DC power supply – 0 to 40 Vdc
- AC source – 120 vac
- Assorted resistors
- Prototype board – Circuit assembly
- Clamp-on ammeter
- Permanent magnets
- Lead wire
- Standard screwdrivers, Phillips screwdrivers, side cutters, wire stripper, soldering iron

Number:	S0376
Title:	**Instrumentation II**
Duration:	Total Hours: 63
	Theory: 30 Hours Practical: 33 Hours
Prerequisites:	None
Co-requisites:	None

Evaluation Structure:

Theory Testing	35%
Practical Exercises	35%
Final Assessment	30%

Number: S0376.1

Title: Instrumentation Test Equipment

Duration: Total hours: 5

Theory: 1
Practical: 4

Prerequisites: None

Co-requisites: None

Cross Reference to Training Standards: 6422.01, 6422.02, 6423.09, 6424.02, 6424.05, 6424.08, 6424.11, 6424.14, 6425.02, 6426.02

GENERAL LEARNING OUTCOMES

Upon successful completion the apprentice is able to calibrate process measuring devices using prescribed test equipment according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.1.1 Identify the types and application of instrumentation test equipment such as:

- Current calibrator
- Explain current loops
- Describe operation of a current source
- Instrument Calibration
  - voltage
  - frequency
  - pressure
  - temperature

2.1.2 Describe the operational features of instrumentation test equipment.

2.1.3 Calibrate process measuring devices using prescribed instrumentation test equipment.

Number: S0376.2

Title: Pressure Measurement

Duration: Total Hours: 12

Theory: 6
Practical: 6

Cross-Reference to Training Standard Performance Objectives: 6424.10, 6424.11, 6424.12,

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GENERAL LEARNING OUTCOMES

On successful completion the apprentice is able to wire, connect, test and calibrate pressure measuring devices as applied to instrumentation and control systems according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.1.4 Describe the fundamentals and characteristics of Pressure Measurement.

- Explain important considerations in pressure measurement applications
- Define Charles's, Pascal's and Boyle's gas laws and the combined gas law

2.1.5 Explain the operating principles of Pressure Measuring devices.

- list and describe accessory signal conditioning devices
- Identify means of protecting pressure sensors from hazardous environments

2.1.6 Wire, connect and calibrate pressure measuring instruments using appropriate standards.

- Perform instrumentation calibration for pressure measuring devices.
- Wire and connect pressure measuring instruments.

Number: S0376.3

Title: Level Measurement

Duration: Total Hours: 10

Theory: 5
Practical: 5

Cross-Reference to Training Standard Performance Objectives: 6424.07, 6424.08, 6424.09

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to wire, connect, test and calibrate level measuring devices as applied to instrumentation and control systems according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.3.1 Describe the fundamentals and characteristics of Level Measurement such as:

- Ultrasonic
- Radar
- Laser
- Nuclear
- Weigh systems such as strain gauges and load cells.
- Buoyancy

2.3.2 Explain the operating principles of level measuring devices.

- Identify means of protecting Level sensors from hazardous environments.
- Explain factors that affect level measurement such as specific gravity, equipment location and pressure.
- Explain important considerations in level measurement applications.
- Describe weigh systems used for level measurement such as strain gauges and load cells

2.3.3 Wire, connect and calibrate level measuring instruments using appropriate standards.

- Perform instrumentation calibration for level measuring devices.
- Wire and connect level measuring instruments.

Number: S0376.4

Title: Temperature Measurement

Duration: Total Hours: 10

Theory: 5
Practical: 5

Cross-Reference to Training Standard Performance Objectives: 6424.04, 6424.05, 6424.06

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to wire, connect, test and calibrate temperature measuring devices as applied to instrumentation and control systems according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.4.1 Describe the fundamentals and characteristics of temperature measurement.

- Define the common units of heat energy.
- Explain the specific heat of a liquid.
- Describe the temperature scales and their relationships.

2.4.2 Explain the operating principles of temperature measuring devices.

- Explain the physics of infrared radiation thermometers and disappearing filament pyrometers.
- Explain the operating principles of temperature measuring elements such as:
  - RTD'S
  - thermistors
  - thermal filled
  - semi-conductor
  - bimetallic

- Describe the function and use of thermowells.
- Describe thermocouple measurement circuits.
- Explain considerations in the use of different types of thermocouples in various environments
- Explain important considerations in temperature measurement applications
- List and describe accessory signal conditioning devices

2.4.3 Wire, connect and calibrate temperature measuring instruments using appropriate standards.

- Perform instrumentation calibration for temperature measuring devices.
- Wire and connect temperature measuring instruments.

Number: S0376.5

Title: Flow Measurement

Duration: Total Hours: 16

Theory: 8
Practical: 8

Cross-Reference to Training Standard Performance Objectives: 6424.01, 6424.02, 6424.03

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to wire, connect, test and calibrate flow measuring devices as applied to instrumentation and control systems according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.5.1 Describe the fundamentals and characteristics of flow measurement such as:

- Define the common units of flow measurement.
- Head flow meters
- Magnetic flow meters
- Mechanical flow meters
- Positive displacements

2.5.2 Explain the operating principles of flow measuring devices.

- Explain important considerations in flow measurement applications.
- List and describe accessory signal conditioning devices.
- Identify means of protecting flow sensors from hazardous environments.
- Explain factors that affect fluid flow such as viscosity, meter location and fluid medium.
- Explain the function and use of impulse lines and 3 valve manifolds.

2.5.3 Wire, connect and calibrate flow measuring instruments using appropriate standards.

- Perform instrumentation calibration for flow measuring devices.
- Wire and connect flow measuring instruments.

Number: S0376.6

Title: Secondary Process Measurement

Duration: Total Hours: 10

Theory: 5
Practical: 5

Cross-Reference to Training Standard Performance Objectives: 6424.13, 6424.14, 6424.15

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to wire, connect, test and calibrate secondary process measuring devices as applied to instrumentation and control systems according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

2.6.1 Describe the fundamentals and characteristics of Secondary Process Measurement such as:

- Density
- Viscosity
- Weight
- Vibration
- Turbidity
- Opacity
- Moisture and humidity
- Speed
- Position
- Consistency
- pH

2.6.2 Explain the operating principles of Secondary Process Measurement.

- List and describe accessory signal conditioning devices
- Identify means of protecting sensors from hazardous environments

2.6.3 Wire, connect and calibrate secondary process measuring instruments using appropriate standards.

- Perform instrumentation calibration for Secondary Process measuring devices.
- Wire and connect Secondary Process measuring instruments.

S0376: RECOMMENDED MINIMUM EQUIPMENT:

- Copper instrument tubing ¼"
- Tubing bender, cutter, reamer
- Assorted tube fittings, compression fittings, hand valves
- Standard screwdrivers, DMM, Crescent wrench, Allen keys, Phillips screwdrivers, pressure calibrator, DWT, current calibrator, safety glasses, lead wire, side cutters, wire stripper, soldering iron
- Pressure standards – Inclined & U tube manometers, pressure calibrator ± .25%, DWT (Dead Weight Tester) and Test gauges
- PRV – Pressure regulating valve
- Compressed air supply (2.5 cfm @ 90 psi min.)
- Variety of pressure indicators – (0 to 100psig, 30" Hg vac to 30 psig, inches or cm of w.c.), Bourdon, Magnehelics
- Variety of pressure switches – (0 to 100 psig)
- Variety of pressure transmitters (25 to 250 in. w.c., 0 to 30 psig) 4 – 20 mA
- Variety of level switches
- Variety of level transmitters
- Variety of temperature indicators (glass thermometers, bimetal, IR non contact)
- Variety of temperature elements
- Variety of temperature switches
- Variety of temperature transmitters
- Flow indicators – rotameters
- Variety of flow switches

- Variety of flow transmitters (Bernoulli types, magmeter, positive displacement, etc.)
- DC supply (minimum 24Vdc @ 100mA)
- Steel pipe and tap & die set (¼" to 1"), assorted pipe fittings
- Instrumentation calibrators (Current, millivolt, pressure)
- Oscilloscopes
- Frequency counters
- Function generators
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Variable DC power supply – 0 to 40 Vdc
- Variety of analyzers (pH/ORP, turbidity, conductivity, DO, etc)

Number: S0377

Title: **Instrumentation And Controls II**

Duration: Total Hours 54

Theory: 29 Hours Practical: 25 Hours

Prerequisites: None

Co-requisites: None

Content:

Evaluation Structure:

Theory Testing	40%
Practical Exercises	30%
Final Assessment	30%

Number: S0377.1

Title: Final Control Elements

Duration: Total Hours 12

Theory: 8
Practical: 4

Cross-Reference to Training Standard Performance Objectives: 6429.01, 6429.02, 6429.03, 6429.04, 6429.05, 6429.06, 6429.07, 6429.08, 6429.09, 6429.10, 6429.11, 6429.12, 6429.13, 6429.14, 6429.15, 6429.16, 6429.17, 6429.18

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to disassemble, assemble, stroke, size and select various types of solenoid valves according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.1.1 Identify various types and applications of control valves and actuators.

- Control valve bodies and their process applications
- Valve trim and their process applications
- Valve packing and their process applications
- Valve guiding
- Self regulating valves
  - temperature
  - pressure
- valve actuators
  - diaphragm
  - piston
  - electric and electro-hydraulic
- Describe the advantages and limitations of various types of valve actuators

3.1.2 Disassemble and assemble control valve assemblies.

3.1.3 Stroke control valve assemblies.

3.1.4 Size and select control valves for various applications.

- Explain the meaning of CV (valve coefficient)

Number: S0377.2

Title: Control System Fundamentals

Duration: Total Hours 30

Theory: 15
Practical: 15

Cross-Reference to Training Standard Performance Objectives: 6429.01, 6429.02, 6429.03, 6429.04, 6429.05, 6429.06, 6429.07, 6429.08, 6429.09, 6429.10, 6429.11, 6429.12, 6429.13, 6429.14, 6429.15, 6429.16, 6429.17, 6429.18

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to wire, connect and calibrate on/off control systems and proportional, integral and derivative control (PID) systems.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.2.1 Explain the principles of on/off control and identify the four basic elements of a control system.
- Process control principles and limitations.

3.2.2 Identify the fundamentals and applications of controllers.

- Identify terminology that applies to process controls
- Identify and become familiar with the various types of controllers
- Define PID control modes (proportional, integral and derivative)

3.2.3 Identify various controller options.

- Identify control device adjustment procedures for various types of controllers.

- Identify indicators for various types of controllers.

3.2.4 Define and explain the principle of proportional, integral and derivative control.

3.2.5 Explain the advantages and limitations of using proportional, integral and derivative control.

- Process control principles and limitations.

3.2.6 Wire, connect and calibrate an on/off control system.

3.2.7 Wire, connect and calibrate a PID control system.

Number: S0377.3

Title: Valve Positioners

Duration: Total Hours 6

Theory: 4
Practical: 2

Cross-Reference to Training Standard Performance Objectives: 6429.01, 6429.02, 6429.03

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability install, calibrate and troubleshoot various types of control valve petitioners according to manufacturer's recommendations and specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.3.1 Identify various types and applications of valve positioners.

- Describe the characteristics of valve positioners
- Pneumatic positioners
- Electric positioners
- Digital smart positioners

3.3.2 Explain the operating principles of valve positioners.

- Pneumatic valve postioner operation
- Electric positioner operation
- Digital smart positioner operation

3.3.3 Install and calibrate various valve positioners.

- Determine calibration values for positioners used in split range applications

Number: S0377.4

Title: Troubleshoot Control Valves

Duration: Total Hours 6

Theory. 2
Practical: 4

Cross-Reference to Training Standard Performance Objectives: 6429.08, 6429.09, 6429.10

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability to troubleshoot common control valve problems according to manufacturer's recommendations.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

3.4.1 Identify common control valve problems.

3.4.2 Perform troubleshooting procedures to diagnose common control valve problems.

S0377: RECOMMENDED MINIMUM EQUIPMENT:

- Variety of automatic control valves –
  - Pneumatic spring & diaphragm globe style
  - Pneumatic rotary valve (Butterfly or Ball)
  - Cage guided control valve
  - Piston actuators
  - Vane type actuators
- ACV trim kit, packing assembly
- DMM, lead wire, socket set, Crescent wrench, open end wrenches, Allen keys, standard screwdriver
- Dial indicator
- Compressed air supply
- Pneumatic calibrator
- PRV
- Variety of valve positioners
- Variety of electronic standalone PID controllers

Number: S0378

Title: **Discrete Control**

Duration: Total Hours 36

Theory: 16
Practical: 20

Prerequisites: None
Co-requisites: None

Evaluation Structure:

- Assignments related to theory and appropriate application skills.
- Final exam at end of term.
- Periodic quizzes.

Theory Testing 25%
Practical Exercises 45%
Final Assessment 30%

Number: S0378.1

Title: Introduction to Discrete Control

Duration: Total Hours 6

Theory: 6
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6431.05, 6431.06, 6431.07, 6431.08

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to demonstrate the ability to describe discrete control devices and circuits used in the instrumentation and controls industry.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

4.1.1 Define the fundamentals of discrete on/off control.

- Input devices such as:
  - limit/reed switches
  - selector switches
  - control relays
  - temperature switches
  - pressure switches
  - level switches
  - pneumatic timers
- Output devices such as:
  - Starters
  - Solenoids
  - relays

4.1.2 Identify limit control devices such as high/low alarms.

4.1.3 Describe the timing and sequencing circuits in conjunction with pilot control devices.

- limit/reed switches
- selector switches
- control relays
- temperature switches
- pressure switches
- level switches
- pneumatic timers

4.1.4 Interpret manufacturer's data sheets.

Number: S0378.2

Title: Control System Electrical Schematics

Duration: Total Hours 10

Theory: 10
Practical: 0

Cross-Reference to Training Standard Performance Objectives: 6423.01

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to read, interpret and draw control system electrical schematics for electrical control circuits that interface with electric motors (single/three phases) and electrical solenoid valves.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

4.2.1 Read and interpret electrical schematic and wiring diagrams associated with complex control operations i.e. (timing and sequencing)

4.2.2 Draw electrical schematics and wiring diagrams associated with complex control operations i.e. (timing and sequencing)

Number: S0378.3

Title: Discrete Control Wiring

Duration: Total Hours 20

Theory: 0
Practical: 20

Cross-Reference to Training Standard Performance Objectives: 6423.05, 6424.01, 6424.04, 6424.07, 6424.10, 6424.13

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to install and connect discrete controls using various pilot devices, starters and motors.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

4.3.1 Install and connect timing and sequencing circuits in conjunction with pilot control devices such as:

- Limit/reed switches
- Selector switches
- Control relays
- Temperature switches
- Pressure switches
- Level switches
- Pneumatic timers

4.3.2 Install and connect discrete control components according to Canadian Electrical Safety Code Part 2, manual and magnetic full voltage (reversing and non-reversing) motor starters.

S0378: RECOMMENDED MINIMUM EQUIPMENT:

- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A)
- Variable DC power supply – 0 to 40 Vdc
- Variety of ON/Off switches (pressure, level, temperature, flow)
- Variety of switches (SPST, SPDT, DPDT)
- Proximity switches
- Variety of relays, contactors, solenoids
- Time delay relay
- Pneumatic air supply, compressor, filter, air dryer

Number: S0379

Title: **Computer Control Systems**

Duration: Total Hours: 39

Theory: 14
Practical: 25

Prerequisites: None
Co-requisites: None

Evaluation Structure:

Theory Testing	20%
Practical Exercises	50%
Final Assessment	30%

Number: S0379.1

Title: Introduction to DCS, PLC and Scada Systems

Duration: Total Hours: 6

Theory: 4

Practical: 2

Cross-Reference to Training Standard Performance Objectives: 6431.01, 6431.02, 6431.03, 6431.04, 6431.05, 6431.06, 6431.07, 6431.08

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to describe Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), Supervisory Control and Data Acquisition (SCADA) and related communication systems.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.1.1 Define the following control systems

- Distributed Control Systems (DCS)
- Programmable Logic Controllers (PLC)
- Supervisory Control and Data Acquisition (SCADA)

5.1.2 Describe the architecture of control systems.

- Distributed Control Systems (DCS)
- Programmable Logic Controllers (PLC)
- Supervisory Control and Data Acquisition (SCADA)

5.1.3 Explain the concept of addressing.

5.1.4 Explain program flow and faults.

5.1.5 Explain trending as used in automated control systems.

5.1.6 Produce a block diagram of a DCS, PLC or SCADA system.

5.1.7 Identify and describe inter-computer communication strategies and hardware used by DCS AND PLC'S.

- *Configure operational software for a DCS and PLC.*

Number: S0379.2

Title: Electrical Circuits and Ladder Diagrams

Duration: Total Hours: 10

Theory: 4
Practical: 6

Cross-Reference to Training Standard Performance Objectives: 6423.01, 6431.01, 6431.02, 6431.03, 6431.04, 6431.05, 6431.06, 6431.07, 6431.08

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able to interpret electrical circuits, design, build and test ladder diagrams for Distributed Control Systems (DCS), and Programmable Logic Controllers (PLC).

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.2.1 Read and interpret electrical ladder diagrams.

5.2.2 Design, build and test electrical circuits from ladder diagrams.

Number: S0379.3

Title: Configuration and Programming

Duration: Total Hours 10

Theory: 3
Practical: 7

Cross-Reference to Training Standard Performance Objectives: 6431.02, 6431.04, 6431.07

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able configure and program Distributed Control Systems (DCS) and Programmable Logic Controllers (PLC) according to operating specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.3.1 Configure and program discrete control systems.

5.3.2 Program basic logic functions timing instructions and counters.

5.3.3 Select specified Input and Output Modules for a given application.

5.3.4 Upload, download and run programs from computer to DCS AND PLC.

Number: S0379.4

Title: Control System Troubleshooting

Duration: Total Hours 10

Theory: 2
Practical: 8

Cross-Reference to Training Standard Performance Objectives: 6423.09, 6431.02, 6431.04

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able troubleshoot Distributed Control Systems (DCS) and Programmable Logic Controllers (PLC) according to operating specifications.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.4.1 Identify control problems for DCS and PLC systems.

5.4.2 Troubleshoot DCS and PLC systems.

Number: S0379.5

Title: System Configuration, Interfacing and Communications

Duration: Total Hours 3

Theory: 1
Practical: 2

Cross-Reference to Training Standard Performance Objectives: 6431.02, 6431.04

GENERAL LEARNING OUTCOMES

On successful completion, the apprentice is able troubleshoot Computer Communication Set-Up procedures for Distributed Control Systems (DCS), Programmable Logic Controllers (PLC) and related communication systems.

LEARNING OUTCOMES

On successful completion, the apprentice is able to:

5.5.1 Set up communications among computers, DCS and PLC

5.5.2 Set up networks among workstations, multiple DCS and PLC

- Explain transmission control protocol/internet protocol (TCP/IP) and its use on computerized systems.

S0379: RECOMMENDED MINIMUM EQUIPMENT:

- PLC (Programmable Logic Controller) – minimum 6 discrete inputs, 4 discrete outputs
- DCS (Distributed Control System) – minimum 6 discrete inputs, 4 discrete outputs
- DMM, lead wire
- DC power supply
- AC power source
- Personal computer for program entry c/w PLC software, network card
- Variety of input devices – manual and automatic switches
- Variety of output devices – lights, motors, relays and solenoids
- Network cables, hub or router
- PLC or DCS communications cards (Ethernet, Profibus, Modbus, ControlNet, etc.)

Summary of Equipment Required for Level II

S0375: Recommended Minimum Equipment:

- Variety of capacitors, inductors, transformers, AC & DC motors
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Oscilloscope and X10 probe
- Variable DC power supply – 0 to 40 Vdc
- AC source – 120 vac
- Assorted resistors
- Prototype board – Circuit assembly
- Clamp-on ammeter
- Permanent magnets
- Lead wire
- Standard screwdrivers, Phillips screwdrivers, side cutters, wire stripper, soldering iron

S0376: Recommended Minimum Equipment:

- Copper instrument tubing ¼"
- Tubing bender, cutter, reamer
- Assorted tube fittings, compression fittings, hand valves
- Standard screwdrivers, DMM, Crescent wrench, Allen keys, Phillips screwdrivers, pressure calibrator, DWT, current calibrator, safety glasses, lead wire, side cutters, wire stripper, soldering iron
- Pressure standards – Inclined & U tube manometers, pressure calibrator ± .25%, DWT (Dead Weight Tester) and Test gauges
- PRV – Pressure regulating valve
- Compressed air supply (2.5 cfm @ 90 psi min.)
- Variety of pressure indicators – (0 to 100psig, 30" Hg vac to 30 psig, inches or cm of w.c.), Bourdon, Magnehelics
- Variety of pressure switches – (0 to 100 psig)
- Variety of pressure transmitters (25 to 250 in. w.c., 0 to 30 psig) 4 – 20 mA
- Variety of level switches
- Variety of level transmitters
- Variety of temperature indicators (glass thermometers, bimetal, IR non contact)
- Variety of temperature elements
- Variety of temperature switches
- Variety of temperature transmitters
- Flow indicators – rotameters
- Variety of flow switches

- Variety of flow transmitters (Bernoulli types, magmeter, positive displacement, etc.)
  DC supply (minimum 24Vdc @ 100mA)
- Steel pipe and tap & die set (¼" to 1"), assorted pipe fittings
- Instrumentation calibrators (Current, millivolt, pressure)
- Oscilloscopes
- Frequency counters
- Function generators
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, mA dc, A ac
- Variable DC power supply – 0 to 40 Vdc
- Variety of analyzers (pH/ORP, turbidity, conductivity, DO, etc)

S0377: Recommended Minimum Equipment:

- Variety of automatic control valves –
  - Pneumatic spring & diaphragm globe style
  - Pneumatic rotary valve (Butterfly or Ball)
  - Cage guided control valve
  - Piston actuators
  - Vane type actuators
- ACV trim kit, packing assembly
- DMM, lead wire, socket set, Crescent wrench, open end wrenches, Allen keys, standard screwdriver
- Dial indicator
- Compressed air supply
- Pneumatic calibrator
- PRV
- Variety of valve positioners
- Variety of electronic standalone PID controllers

S0378: Recommended Minimum Equipment:

- Standard screwdrivers, Phillips screwdrivers, prototype board, side cutters, wire stripper, soldering iron
- DMM (Digital Multi Meter) – Scales for DC volts, AC volts, DC amps (0 – 2A),
  AC amps (0 – 10A)
- Variable DC power supply – 0 to 40 Vdc
- Variety of ON/Off switches (pressure, level, temperature, flow)
- Variety of switches (SPST, SPDT, DPDT)
- Proximity switches
- Variety of relays, contactors, solenoids
- Time delay relay
- Pneumatic air supply, compressor, filter, air dryer

S0379: Recommended Minimum Equipment:

- PLC (Programmable Logic Controller) – minimum 6 discrete inputs, 4 discrete outputs
- DCS (Distributed Control System) – minimum 6 discrete inputs, 4 discrete outputs
- DMM, lead wire
- DC power supply
- AC power source
- Personal computer for program entry c/w PLC software, network card
- Variety of input devices – manual and automatic switches
- Variety of output devices – lights, motors, relays and solenoids
- Network cables, hub or router
- PLC or DCS communications cards (Ethernet, Profibus, Modbus, ControlNet, etc.)